AD_____
(Leave blank)

Award Number:
W81XWH-08-1-0302

TITLE:
Incidence of Upper Extremity Nerve Entrapments in Veterans with Major Limb Amputations

PRINCIPAL INVESTIGATOR:
Rory A. Cooper, Ph.D.

CONTRACTING ORGANIZATION:
Veterans Research Foundation
Pittsburgh, PA 15206-1206

REPORT DATE:
March 2009

TYPE OF REPORT:
Final

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: (Check one)

√ Approved for public release; distribution unlimited

□ Distribution limited to U.S. Government agencies only; report contains proprietary information

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

| **1. REPORT DATE** *(DD-MM-YYYY)* | **2. REPORT TYPE** | **3. DATES COVERED** *(From - To)* |
|---|---|---|
| 24-03-2009 | Final | 25 MAR 2008 - 24 FEB 2009 |

**4. TITLE AND SUBTITLE**
Incidence of Upper Extremity Nerve Entrapments in Veterans With Major Limb Amputations

**5a. CONTRACT NUMBER**
W81XWH-08-1-0302

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**

**6. AUTHOR(S)**
Rory A. Cooper, Ph.D.

**5d. PROJECT NUMBER**

**5e. TASK NUMBER**

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Veterans Research Foundation
7180 Highland Drive
Pittsburgh, PA 15206-1206

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
U.S. Army Medical Research
And Materiel Command
Fort Detrick, Maryland
21702-5012

**10. SPONSOR/MONITOR'S ACRONYM(S)**

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

**12. DISTRIBUTION / AVAILABILITY STATEMENT**
Approved for Public Release; distribution unlimited

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

**Objective:** The purpose of this pilot study was to examine the prevalence and severity of upper extremity nerve entrapment syndromes in a sample of veterans with lower limb amputations. **Design:** Twenty participants were recruited at the 2008 National Disabled Veterans Winter Sports Clinic. All study participants provided written informed consent and completed a questionnaire which included symptomotology, past medical history, time since amputation, medication history, assistive technology history, and wheelchair information. A physical exam was performed on each subject to assess for thenar/hypothenar atrophy, deep tendon reflexes, strength testing, sensory testing with pinprick and light touch, Tinel's test at the elbow and wrist, and Phalen's test. All nerve conduction studies were performed by American Board of Electrodiagnostic Medicine certified physiatrists. **Results:** A total of 20 subjects (19 male and 1 female) with a mean age of 59±13 years were enrolled in the study. A total of 16/20 (80%0 subjects had electrodiagnostic findings consistent with median neuropathy across the wrist (26/38 affected limbs, 6 subjects with unilateral and 10 subjects with bilateral findings), and 14/20 (70%) subjects had ulnar entrapment neuropathy across the elbow (22/38 affected limbs, 6 subjects with unilateral and 8 subjects with bilateral findings). Several subjects (6/20, 30%) were found to have electrodiagnostic evidence of ulnar entrapment neuropathy across the wrist (10/38 affected limbs, 2 unilateral and 4 bilateral findings). **Conclusion:** Although this was a pilot study, we identified a high number of veterans with nerve entrapment syndromes.

**15. SUBJECT TERMS**
Nerve Entrapment Syndromes, Upper Extremity and Lower Limb Amputations (LLA), Adaptive Winter Sports, Electrodiagnostic Findings

| **16. SECURITY CLASSIFICATION OF:** | | | **17. LIMITATION OF ABSTRACT** | **18. NUMBER OF PAGES** | **19a. NAME OF RESPONSIBLE PERSON** |
|---|---|---|---|---|---|
| **a. REPORT** | **b. ABSTRACT** | **c. THIS PAGE** | | | **19b. TELEPHONE NUMBER** *(include area code)* |
| U | U | U | UU | 7 | USAMRMC |

## Table of Contents

**Page**

**Introduction…….. 4**

**Body……..4-5**

**Key Research Accomplishments…….. 5**

**Reportable Outcomes……5-6**

**Conclusion…….. 6**

**References……6-7**

# *Upper limb nerve entrapment syndromes in veterans with lower limb amputations.*

Jay Pyo, DO[1], Paul F. Pasquina, MD[1], Michael DeMarco, DO[1], Robert Wallach, DO[4], John Santa Ana, DO[1],

Emily Teodorski, BS[2, 3], Rory A. Cooper, PhD[2, 3]

1. Physical Medicine and Rehabilitation Service, Department of Orthopedics and Rehabilitation, Walter Reed Army Medical Center, Washington, DC.

2. Human Engineering Research Laboratories, Department of Veterans Affairs Pittsburgh Healthcare System, Pittsburgh, PA.

3. Department of Rehabilitation Science & Technology, University of Pittsburgh, Pittsburgh, PA.

4. Physical Medicine and Rehabilitation Service, Department of Orthopedics, Madigan Army Medical Center, Tacoma, Washington.

## Introduction

The 2008 National Disabled Veterans Winter Sports Clinic (NDVWSC), held in Snowmass, Colorado is an arena where veterans with disabilities have an opportunity to train in various adaptive winter sports. People with lower limb amputations (LLA) typically depend on assistive technology (AT) devices, such as crutches or wheelchairs, for all or part of their mobility and Activities of Daily Living (ADLs). As a result of repetitive motion of hands and wrists and positioning of joints that may cause compression of neural structures, there may be increased risk for nerve entrapment syndromes as a result of overuse activity. Nerve entrapment syndromes (NES) are some of the most common reasons for obtaining electrodiagnostic studies (1, 11-12). In the past, researchers have studied NES in AT users in other populations such as people with spinal cord injuries and wheelchair athletes. These studies showed a prevalence of median neuropathy of up to 50% and ulnar neuropathy of up to 25% (2-5). However, there are few published studies examining NES in individuals with LLA. The purpose of this pilot study was to examine the prevalence and severity of upper extremity NES in a sample of veterans with LLA.

## Body

Twenty participants were recruited at the 2008 NDVWSC. Criteria for enrollment in the study were participation in the NDVWSC, age 18 to 80, with LLA, use AT for mobility or ADLs, and without cardiac pacemaker.

All study participants provided written informed consent and completed a questionnaire which included symptomotology, past medical history, time since amputation, and history of AT use. A physical exam was performed on each subject to assess for thenar/hypothenar atrophy, deep tendon reflexes, strength testing, sensory testing with pinprick and light touch, Tinel's test at the elbow and wrist, and Phalen's test.

All nerve conduction studies (NCS) were performed and supervised by American Board of Electrodiagnostic Medicine certified physiatrists, using an Xltec NeuroMax EMG. Filter cut-off

frequencies were set at 10Hz and 2kHz for sensory studies and 2Hz and 10kHz for motor studies. Limb temperatures were held $\geq$ 32 degrees C.

Median motor NCS were performed with orthodromic responses recorded over the abductor pollicis brevis using 1cm disc electrodes and supramaximal stimulation proximal to the recording electrode at a distance of 8cm and in the antecubital fossa, respectively (7, 11-12).

Ulnar motor NCS were performed with orthodromic responses recorded over the abductor digiti minimi using 1cm disc electrodes. Supramaximal simulation proximal to the recording electrode was performed at a distance of 8cm. Supramaximal below-elbow stimulation was performed with the elbow flexed to 90 degrees at a distance of 3cm distal to the medial epicondyle and above-elbow stimulation was performed with the elbow flexed to 90 degrees at a distance of 4cm proximal to medial epicondyle (6, 8, 11-12).

Combined sensory index (CSI) was also performed and interpreted. Three sets of NCS were performed on each arm which included median-ulnar midpalmar orthodromic difference at 8cm (palmdiff); median-ulnar digit four antidromic differences at 14cm (ringdiff); and median-radial digit one antidromic difference at 10 cm (thumbdiff) (9-10).

## Key Research Accomplishments

- Examines the prevalence and severity of upper extremity NES in veterans with Lower Limb Amputation where only a few studies have been published examining NES in individuals with Lower Limb Amputations

- Suggests future study designs to understand the electrodiagnostic relationship between specific demographic groups and studies evaluating assistive technology in relation to biomechanics and the design of more ergonomic devices

- Raises physician awareness of the importance of early identification of NES in Lower Limb Amputees for effective intervention and that proper fit and alignment of Assistive Technology is critical and can reduce the risk of overuse related injuries

## Reportable Outcomes

A total of 20 subjects (19 male and 1 female), who met the inclusion criteria, with a mean age of 59$\pm$13 years were enrolled in the study, 16/20 (80%) had unilateral LLA (one subject had an upper and LLA) and 4/20 (20%) had bilateral LLA. Subjects reported 14/20 (70%) AT use of > 40 hours/week and 6/20 (30%) subjects used only their prostheses. We found that 12/18 subjects reported positive clinical symptoms for CTS or ulnar neuropathy including paresthesias and dysesthesias affecting the digits, decreased dexterity or grip strength, loss of sensation, or the

"flick sign". We found that 14/20 people had positive physical exam findings for CTS, ulnar neuropathy or both.

Electrodiagnostic evidence of NES was examined for 38 limbs: one subject had an arm amputation, another had extensive soft tissue injuries and scar formation. We found that 16/20 (80%) subjects had electrodiagnostic findings consistent with CTS (26/38 affected limbs, 6 subjects with unilateral and 10 with bilateral findings). There were 14/20 (70%) subjects with ulnar entrapment neuropathy at the elbow (UNE) (22/38 affected limbs, 6 subjects with unilateral and 8 with bilateral findings). Several subjects, 6/20 (30%), were found to have electrodiagnostic evidence of ulnar entrapment neuropathy at wrist (UNW) (10/38 affected limbs, 2 subjects with unilateral and 4 with bilateral findings). Furthermore, 7/20 (35%) subjects were diagnosed with mononeuropathies (4 CTS, 3 UNE) and 13/20 (65%) subjects with multiple mononeuropathies. The subjects who were diagnosed with CTS, 9 limbs were considered mild, 11 moderate, and 7 severe (7, 11-12).

## Conclusions

This is the first known study to characterize the prevalence of NES in people with LLA. Surprisingly, all subjects who were studied presented with electrodiagnostic findings of NES. However, 2 subjects had no clinical findings and 8 subjects presented with equivocal clinical findings for NES. Several of these patients were being treated for neuropathic pain masking the intensity or severity of the reporting of symptoms.

Future study designs with a greater number of subjects may help better understand the electrodiagnostic relationship between specific demographic groups, such as primary ambulators compared with primary wheelchair or crutch users, or people with amputations compared with those with bilateral amputation and the general population. Studies evaluating the intensity and duration of AT use may help better identify the biomechanics related to overuse patterns which could aid in design of more ergonomic devices.

Physicians should be aware of the high prevalence of NES in LLA. It is critical to identify the symptoms of NES early in order to effectively intervene. It is also important to note that there may be a subpopulation of individuals with LLA who have electrodiagnostic findings but who do not present with any symptoms. Proper fit and alignment of AT used by individuals with LLA warrants careful evaluation and investigation. This would ultimately encourage appropriate use and better self awareness thereby reducing the risk of overuse related injuries.

## References


1. Patterson JD, et al. Outcomes assessment in carpal tunnel syndrome. *Hand Clin.* 2002;18(2):359–63.
2. Gellman H, et al. Late complications of the weight-bearing upper extremity in the paraplegic patient. *Clin Orthop Relat Res*. 1988;132-5.

3. Boninger ML, et al. Wheelchair Pushrim Kinetics, Weight and Median Nerve Function. *Arch Phyl Med Rehabil* 99 A.D.;910-5.
4. Boninger ML, et al. Upper Limb Nerve Entrapments in Elite Wheelchair Racers. *Am J Phys Med Rehabil*. 75(3), 170-6, May/June 1996.
5. Gellman H, et al. Carpal tunnel syndrome in paraplegic patients. *JBJS* 1988; 70: 517-519.
6. Kincaid JC. AAEM Minimonograph #31: The Electrodiagnosis of Ulnar Neuropathy at the Elbow. *Muscle Nerve* 1998; 11(10): 1005-1015.
7. Stevens JC. AAEM Minimonograph #26: The Electrodiagnosis of Carpal Tunnel Syndrome. *Muscle Nerve* 1997; 20(12): 1477-1486.
8. Landau ME, et al. Optimal Screening Distance for Ulnar Neuropathy at the Elbow. *Muscle Nerve* 2003; 27(5): 570-574.
9. Robinson LR, et al. Optimizing the number of tests for carpal tunnel syndrome. *Muscle Nerve* 2000; 23(12): 1880-1882.
10. Robinson LR, et al. Strategies for analyzing nerve conduction data: superiority of a summary index over single tests. *Muscle Nerve* 1998; 21: 1166-1171.
11. Preston D, Shapiro B. *Electromyography and Neuromuscular Disorders, Edition 2*. 2005.
12. Dumitru D, Amato AA, Zwarts MJ. *Electrodiagnostic Medicine, 2nd Edition*. 2002.

## Acknowledgements

We acknowledge the contributions of Brad Dicianno, MD and Christian Niyonkuru in the production and review of this paper.